Lasers in Neurological Surgery

To THE EDITOR: I have read with interest the review article on lasers in neurosurgery by Drs. Edwards, Boggan, and Fuller (Edwards MSB, Boggan JE, Fuller TA: The laser in neurological surgery. J Neurosurg 59: 555–566, October, 1983). There were some relevant publications by Jain available at the time of final acceptance of their article that should have been included in the references.

The authors failed to mention tissue-welding, which is an important application of lasers in addition to coagulation and vaporization of tissues. The most useful application of tissue-welding is for sutureless microvascular anastomosis using the Nd:YAG laser, the operating microscope, and the micromanipulator. This was developed by me in 1978. Contrary to the statement of Edwards, et al., long-term studies have been done on this procedure, and it has proven useful in clinical applications. The distinct advantages of the laser technique over the suture technique for microvascular anastomosis are as follows:

1. No damage to the vessel wall, as occurs with repeated needle punctures and handling with forceps.
2. Speed: the procedure can now be performed in less than 3 minutes compared to the 15 minutes required for the suture anastomosis. The advantages of such a short occlusive time in the case of a cerebral artery are obvious.
3. No foreign body (in the form of a suture) is left in the vessel wall.
4. Results of laser anastomosis are more uniform, even when performed by surgeons with varying degrees of manual skill. The patency rate is nearly 100%.

The authors state: “Similar small-vessel anastomoses and repairs have been performed with an Ar [argon] laser by us.” According to Dr. Edwards (MSB Edwards: Paper presented at the Second Congress of Laser Neurosurgery, Chicago, September 25, 1982), an argon laser anastomosis does not have tensile strength and can rupture. In a discussion of his paper at that meeting, I pointed out that I had tried vascular anastomosis with argon and CO2 lasers and discarded these in favor of the Nd:YAG laser, which until today remains the only technique of sutureless microvascular anastomosis with tensile strength. The recently developed technique of Neblett using a low-power CO2 laser (CR Neblett, unpublished data), to which the authors refer, involves the use of sutures in addition to the lasers. I have personally witnessed Neblett’s procedure at the laser symposium at the European Congress of Neurosurgery in Brussels, September, 1983. The authors also refer to Beck, et al., as having performed argon laser microvascular repair. This is incorrect. Dr. Beck has never done this procedure nor does he claim to have done so. The mechanism of blood vessel anastomosis with the Nd:YAG laser involves heat-induced changes in the collagen of the media. The CO2 laser with its lack of penetration cannot achieve this effect, but is adequate for superficial welding of tissues, such as dura mater, where no tensile strength is required.

Edwards, et al., state: “With this ‘rapid super-pulsing,’ compared to continuous-wave CO2 laser, tissue coagulation necrosis was decreased…” My personal experience is to the contrary. Damage to brain tissue with this rapid super-pulse technique is very extensive, although the cut surface appears to be clean and there are no carbon deposits or coagulation necrosis. The damage is due to non-thermal mechanical factors, and such lasers are not suitable for neurosurgery.

In their Table 5, the authors indicate that they found the CO2 laser “very helpful” in 12 cases of meningioma. They did not specify the location of these tumors. In vascular meningiomas of the convexity, the CO2 laser alone, without prior radiation with the Nd:YAG laser, is inadequate. The maximum usefulness of the CO2 laser is in removing the medial portion of a sphenoid wing meningioma wrapped around the internal carotid artery. The authors’ impressions of whether the laser was “very helpful” or “helpful” in a certain procedure are conjectural. The large number of cases in which the laser has been used is not proof of the usefulness of these devices. The only convincing advantages are shown by laser procedures that cannot be performed by conventional techniques and by those that extend the present limits of neurosurgery. I consider lasers an important component of the “micromanipulative automated computerized neurosurgical” systems now being developed for the neurosurgery of the future.

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References
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RESPONSE: We thank Dr. Jain for his interest in our article, but we disagree with his views. Tissue-welding by laser energy is an experimental procedure; its clinical utility has not yet been established, and the available data do not justify the widespread purchase of laser devices for this purpose. At the low power settings required for laser-assisted microvascular anastomoses, the resonators of most standard surgical lasers produce unstable power outputs. To our knowledge, Dr. Jain’s micromanipulator has not been described in detail, is not commercially available, and uses a focal length lens (30 mm) that suggests it is a modification of a handheld device.

Our recently reported experience, which corroborates that of Dew, using argon, CO2, and Nd:YAG microsurgical lasers to perform microvascular anastomoses, reveals no significant qualitative difference in the tissue welds produced by these lasers. Anastomoses of similar tensile strength can be created by compensating for differences in absorption, scattering, and penetration, which determine the production and distribution of tissue heat. These characteristics are specific to the laser wavelength and the composition of the target tissue. During anastomosis, the production of heat within the vessel wall causes a full-thickness injury, including the endothelium, at the anastomotic site. The “healing” response to this injury is an endothelial-lined scar without regeneration of the elastic laminae and muscularis. In fact, Dr. Jain has reported creating aneurysms by irradiating rat carotid arteries with the Nd:YAG laser. We are impressed with Dr. Jain’s ability to achieve everted-edges and intima-to-intima anastomoses without manipulating the vessels. Fasano, et al., have found that all three lasers have almost identical effects on vessel elastance.

Nebbett has used a prototype low-power CO2 laser in over 400 anastomosis procedures (CB Nebbett, personal communication). His experience, like that of Dew, indicates that the weld is quite strong; sutures were used only to facilitate approximation of the tissue edges and to label the anastomotic site for later histological study. Although tissue penetration by CO2 laser beams is less than 0.2 mm, this depth is adequate for anastomosing small blood vessels.

In shortening our original manuscript, we deleted references to work on tissue-welding performed in the laboratory of Dr. Auths. When the references were renumbered, Beck was inappropriately cited as having performed argon laser anastomoses.

The experiments by Fuller, et al., on the effects of rapid super-pulsed CO2 lasers, supported by those of Atsumi (presented at the Fourth Congress of the International Society for Laser Surgery, Tokyo, Japan, November, 1981), were not performed on brain tissue. To minimize tissue injury by high-energy pulsed lasers, the pulse rate and duration must allow for thermal relaxation of the target tissue between laser pulses. The total energy per pulse, rate, and exposure determine the average power delivered to the tissue. One must be aware that the tissue damage threshold with continuous-wave lasers is significantly different from that of pulsed lasers. We routinely use the rapid super-pulsed mode (500-W peak transients) on our CO2 surgical laser to excise very tough or large tumors.

There is no doubt that surgical lasers can decrease the mechanical trauma to surrounding normal tissues when used to remove strategically placed firm and adherent tumors. In his review article, Dr. Jain suggests that the CO2 laser is indicated for resection of virtually all intracranial tumors, for skull excision in craniostenosis, for dissection of the temporal artery during superficial temporal artery to middle cerebral artery bypass procedures, and for dissection in lumbar laminectomy/disc operations. Since his review, unlike his letter, did not include reports of his clinical experience, it seems unjustified for Dr. Jain to relegate our experience, and presumably that of others, to the realm of conjecture. We hope and expect that advances in the utilization of lasers will “extend the present limits of neurosurgery.” However, we have maintained Dr. Leon Goldman’s dictum: “If you don’t need a surgical laser, don’t use it.”

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References